70364631 EP/A

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 397 521 A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 90305107.6

(51) Int. Cl.⁵: F02B 69/06, F02D 23/02

(22) Date of filing: 11.05.90

(30) Priority: 11.05.89 JP 118474/89

(43) Date of publication of application: 14.11.90 Bulletin 90/46

(84) Designated Contracting States: DE FR GB

(71) Applicant: ISUZU CERAMICS RESEARCH INSTITUTE CO., LTD.
8, Tsuchidana
Fujisawa-shi Kanagawa 252(JP)

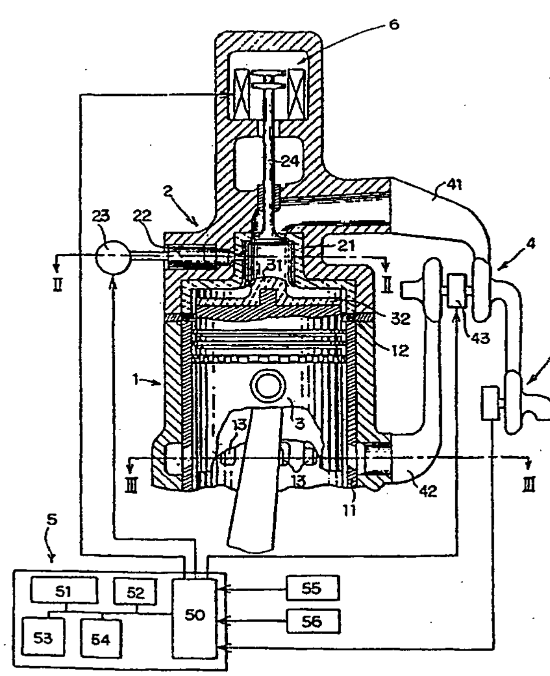
(72) Inventor: Kawamura, Hideo
13-5, Okada 8-chome, Samukawa-machi
Koza-gun, Kanagawa(JP)

(74) Representative: Brunner, Michael John et al
GILL JENNINGS & EVERY 53-64 Chancery Lane
London WC2A 1HN(GB)

(54) Engine cycle control system.

(57) An engine cycle control system controls an engine so that it operates in a two-cycle mode when the rotational speed of the engine is lower than a predetermined speed and in a four-cycle mode when the rotational speed of the engine is higher than the predetermined speed. The engine controlled by the engine cycle control system (5) has intake ports (13) defined in a lower circumferential surface of a cylinder (1), an exhaust port defined in an upper portion of the cylinder and openable and closable at variable timing, and a fuel injection valve (22) for injecting fuel into the cylinder at variable timing and in a variable quantity. Depending on the rotational speed of the engine, the timing of operation of an exhaust valve is varied to select the two-cycle mode or the four-cycle mode. The engine is associated with a turbocharger (4) combined with an electric motor (43). In a large-load range in the two-cycle mode, the electric motor is energized to assist in turbocharging operation for thereby increasing the torque produced by the engine.

Fig. 1



EP 0 397 521 A1

er unit for motor vehicles, then the number of gear positions of a transmission combined with the engine may be reduced or eliminated.

The above and other objects, features and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which preferred embodi ments of the present invention are shown by way of illustrative example.

In the accompanying drawings:-

Fig. 1 is a cross-sectional view, partly in block form, of an engine cycle control system according to an embodiment of the present invention;

Fig. 2 is a cross-sectional view taken along line II - II of Fig. 1;

Fig. 3 is a cross-sectional view taken along line III - III of Fig. 1;

Fig. 4 is a cross-sectional view of a valve actuator;

Fig. 5 is a graph showing a pressure vs. volume (p - v) diagram of a four-cycle engine;

Fig. 6 is a diagram showing certain strokes of the four-cycle engine; and

Fig. 7 is a flowchart of a control sequence of the engine cycle control system according to the present invention.

An engine cycle control system according to an embodiment of the present invention will be described with reference to Figs. 1 through 3.

A cylinder sleeve 11 is fitted against the inner wall of a cylinder 1. A piston 3 is reciprocally fitted in the cylinder 1. The cylinder sleeve 11 has a circum ferential array of intake ports 13 defined in its peripheral wall. The intake ports 13 are positioned such that they are near the upper end of a piston head of the piston 3 when the piston 3 reaches the bottom dead center. The intake ports 13 are inclined with respect to the central axis of the cylinder 1 for introducing swirling intake air into the cylinder 1.

The engine has a prechamber 2 defined centrally in a portion above the cylinder 1 and having an inner wall covered with a sleeve 21 which is made of a heat-resistant heat insulating material such as ceramic. The sleeve 21 and the cylinder sleeve 11 are connected to each other through a heat insulating gasket 12.

An injection nozzle 22 is disposed laterally of the prechamber 2, for injecting fuel into the prechamber 2 along swirls in the prechamber 2 (see Fig. 2). The injection nozzle 22 is connected to a fuel pump 23 by which the timing to inject fuel and the amount of fuel to be injected can be varied. The prechamber 2 has an exhaust port for discharging exhaust gases through the prechamber 2. The exhaust port can be opened and closed by an exhaust valve 24, which is axially movable by a valve actuator 6 disposed around the shank of the exhaust valve 24.

The piston head surface of the piston 3 disposed in the cylinder 1 is covered with a heat-resistant heat insulating material such as ceramic, as with the prechamber 2. The piston 3 has a projection 31 extending from the center of the piston head toward the prechamber 2. When the piston 3 reaches a position near the top dead center of its stroke, the projection 31 narrows the opening of the prechamber 2.

Exhaust gases discharged from the exhaust port are led through an exhaust pipe 41 to the turbine of a turbocharger 4. The turbocharger 4 has a rotatable shaft to which a rotary electric machine 43 is connected. When the rotary electric machine is energized by electric power supplied from an external power supply, it can develop a boost pressure.

The exhaust gases which have gone past the turbocharger 4 are led to a recovery turbine 44 by which remaining heat energy of the exhaust gases is converted into electric energy which is recovered by a control unit 5.

The compressor of the turbocharger 4 can be rotated by the energy of the exhaust gases applied to the turbine or the electric energy supplied to the rotary electric machine, for supplying intake air under boost pressure through an intake pipe 42 to the intake ports 13.

The valve actuator 6, the fuel pump 23, and the rotary electric machine 43 are controlled by signals supplied from an input/output interface 50 of the control unit 5. To the input/output interface 50, there are connected a rotation sensor 55 for detecting the rotational speed and crankshaft angle of the engine, an accelerator pedal move ment sensor 56 for detecting the amount of depression of the accelerator pedal associated with the engine, and an electric generator of the recovery turbine 44. Therefore, signals from these sensors and recovered electric energy are applied to the control unit 5.

The control unit 5 comprises, in addition to the input/output interface 50, a ROM 53 for storing a control program and various tables, a CPU 51 for effecting arithmetic operations under the control of the control program stored in the ROM 53, a RAM 54 for temporarily storing the results of the arithmetic operations and data, and a control memory 52 for controlling the flow of signals in the control unit 5.

The valve actuator 6 will be described in detail below with reference to Fig. 4

Two permanent magnets 61, 62 are fitted over the end of the shank of the exhaust valve 24 in axially spaced relationship. The permanent magnets 61, 62 have respective outer peripheral por-

the air swirls as they go into the prechamber 2.

Then, fuel is injected from the injection nozzle 22 into the prechamber 2 along the air swirls. The injected is fuel is now ignited and fully combusted, producing exhaust gases which lower the piston 3. When the piston 3 is lowered, the opening of the prechamber 2 which has been narrowed by the projection 31 is enlarged, allowing the exhaust gases to be spread quickly into the cylinder 1. On the downward movement of the piston 3, the exhaust valve 24 is actuated to open the exhaust port for thereby discharging the exhaust gases. The above cycle is repeated following the next intake stroke.

A control sequence of the engine cycle control system for controlling the engine will be described below with reference to Fig. 7.

The rotational speed N of the engine is detected on the basis of the signal from the rotation sensor 55 in a step S1. In a next step S2, the load L on the engine is calculated from the signal from the accelerator pedal movement sensor 56 and the rotational speed N detected in the step S1. Then, a step S3 compares the engine rotational speed N and a predetermined rotational speed, which is 2000 rpm in the embodiment. If the rotational speed N is lower than 2000 rpm, then control goes from the step S3 to a step S4, and if the rotational speed N is higher than 2000 rpm, then control goes from the step S3 to a step S9.

In the step S9, the timing of operation of the valve actuator 6 is set to a four-cycle timing which is stored in the control unit 5. Then, in a step S10, the timing of operation of the fuel pump 23 is also set to a four-cycle timing which is stored in the control unit 5. Thereafter, the amount of depression of the accelerator pedal is detected in a step S11, and the amount of fuel to be injected is set on the basis of the detected accelerator pedal depression in a step S12.

The step S4 and a following step S5 are similar to the steps 9 and 10, except that the timings of operation of the valve actuator 6 and the fuel pump 23 are set to two-cycle timings, respectively.

In a step S6, the engine load L calculated in the step S2 is compared with a maximum load Lmax which corresponds to the engine rotational speed N. If the engine load L is larger than the maximum load Lmax, then electric energy is supplied to the rotary electric machine 43 to operate the latter as a motor in a step S7, thereby increasing the boost pressure. In a next step S8, the amount of fuel to be injected is increased from a preset amount, thereby increasing the engine output power.

If the engine load L is smaller than the maximum load Lmax in the step S6, then control proceeds to a step S13 in which the amount of depression of the accelerator pedal is detected, as with the step S11. Then, the amount of fuel to be injected is set in a step S14.

Claims

1. An engine cycle control system for controlling an engine so as to be selectively operable in different cycle modes depending on the rotational speed thereof, comprising:
a cylinder;
a piston reciprocally disposed in said cylinder and having a piston head surface;
an intake port defined in a circumferential surface of said cylinder and positioned such that the intake port positionally corresponds to said piston head surface when said piston reaches a position near the bottom dead center thereof;
an exhaust port defined in an upper portion of said cylinder;
an exhaust valve for opening and closing said exhaust port;
rotation detecting means for detecting a rotational speed of the engine;
load detecting means for detecting a load on the engine;
valve actuator means for actuating said exhaust valve to open and close said exhaust port;
supercharging means for supplying intake air under pressure through said intake port into said cylinder;
supercharging assisting means for assisting in supercharging operation of said supercharging means;
a fuel injection nozzle disposed in the upper portion of said cylinder and operable by a control signal for injecting fuel into said cylinder at a prescribed timing;
cycle mode selecting means for controlling said valve actuator means to operate said exhaust valve each time the engine makes one revolution and also controlling said fuel injection nozzle to eject fuel each time the engine makes one revolution, thereby operating the engine in a two-cycle mode, when the rotational speed of the engine detected by said rotation detecting means is lower than a predetermined speed, and for controlling said valve actuator means to operate said exhaust valve each time the engine makes two revolutions and also controlling said fuel injection nozzle to eject fuel each time the engine makes two revolutions, thereby operating the engine in a four-cycle mode, when the rotational speed of the engine detected by said rotation detecting means is higher than the predetermined speed; and
supercharging control means for operating said supercharging assisting means when the load on the engine detected by said load detecting means is greater than a predetermined load while the

Fig. 1

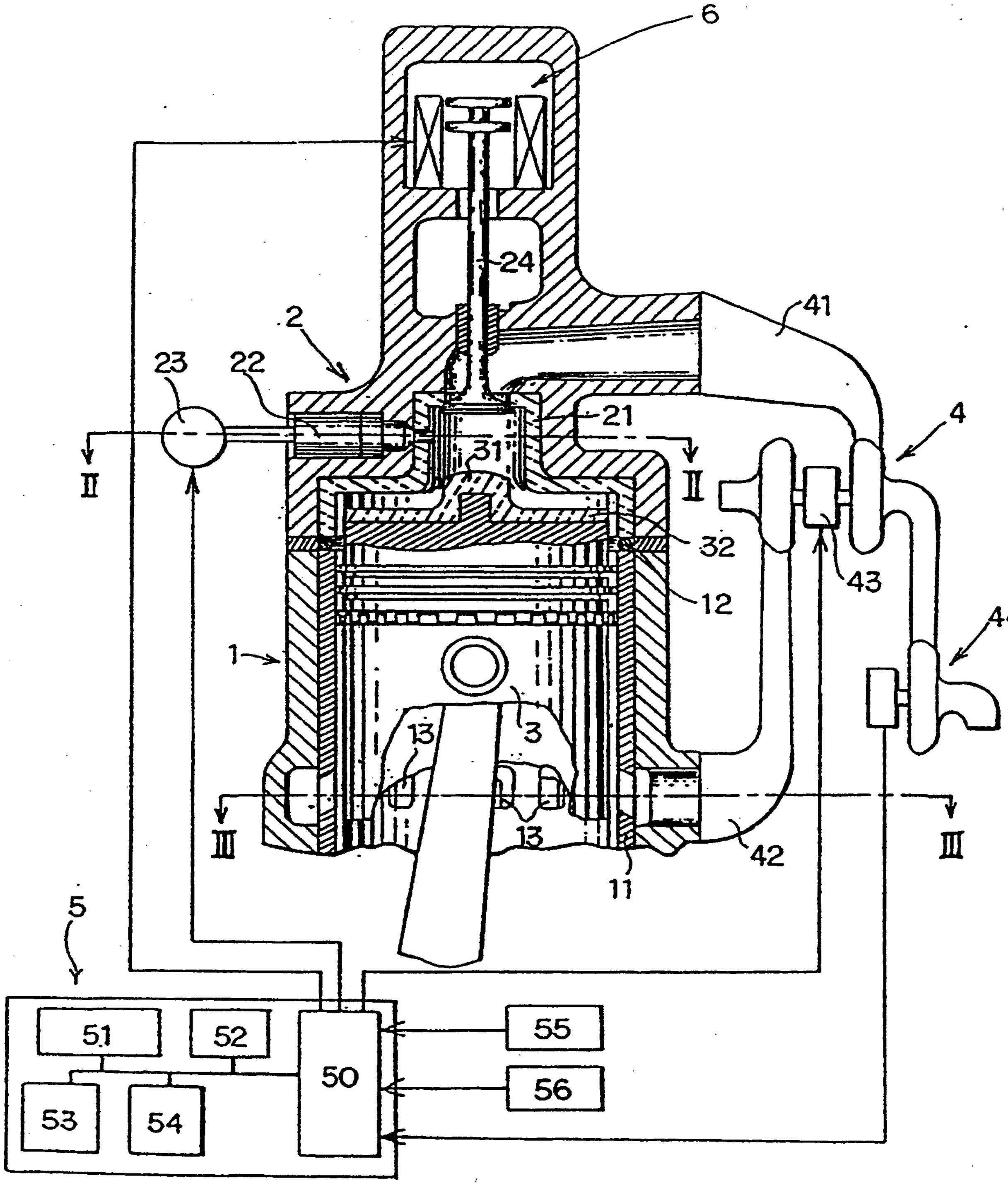

6
24
41
2
23
22
21
31
4
II
II
32
43
12
44
1
3
13
13
III
III
42
11
5
51
52
50
55
56
53
54

Fig. 2

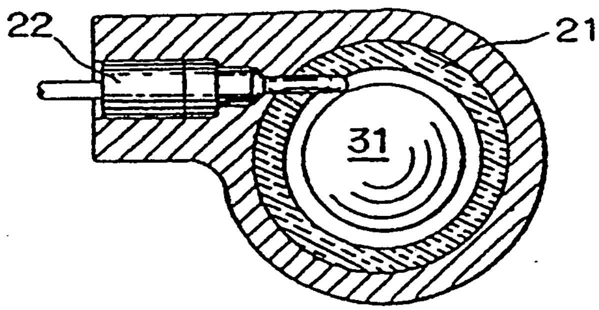


Fig. 3

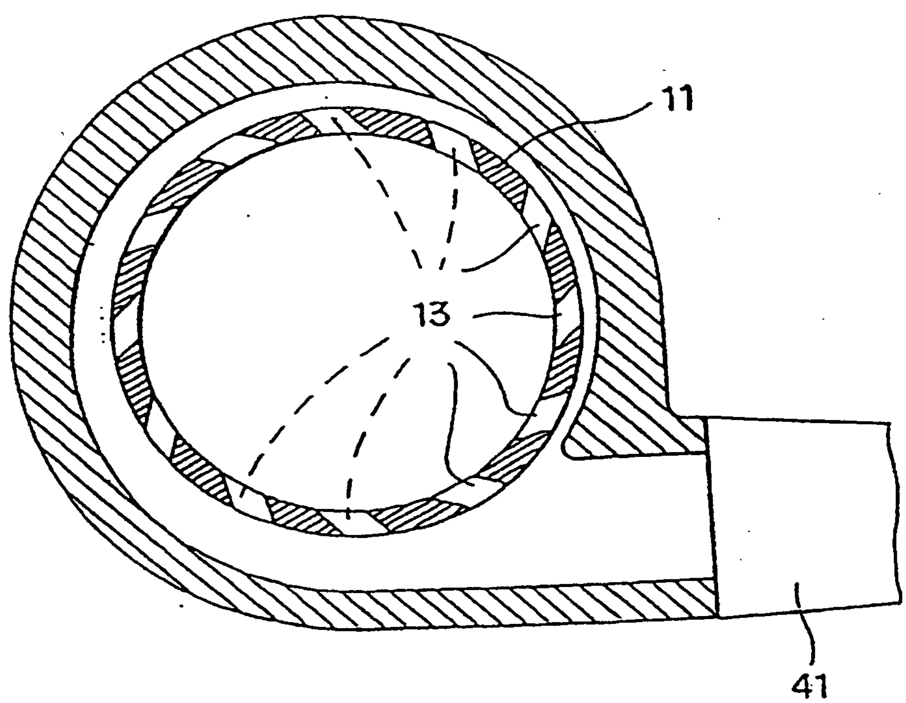


Fig. 4

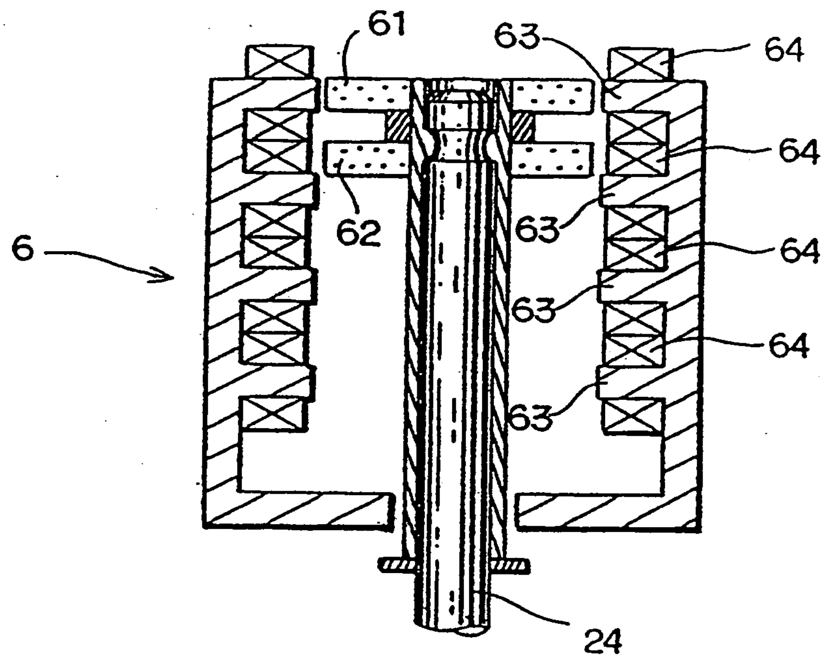


Fig. 5

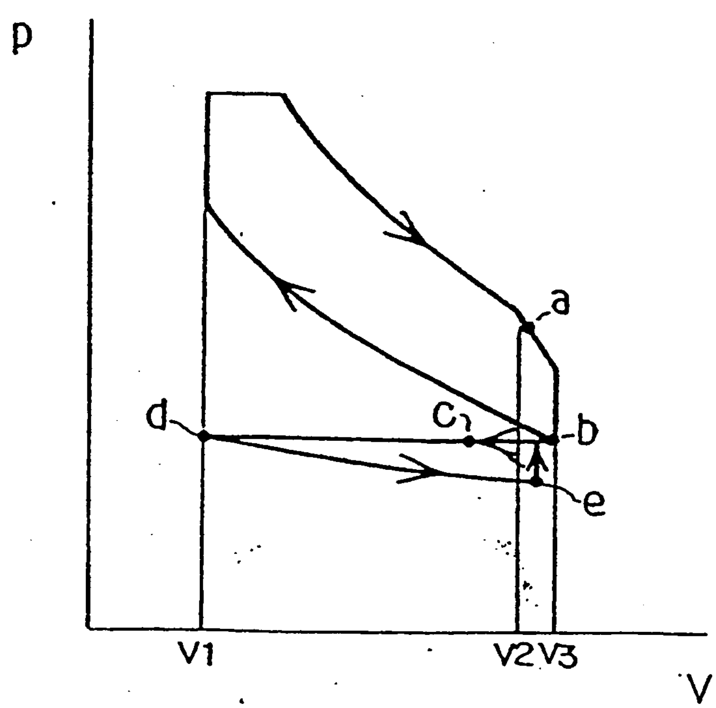


Fig. 6

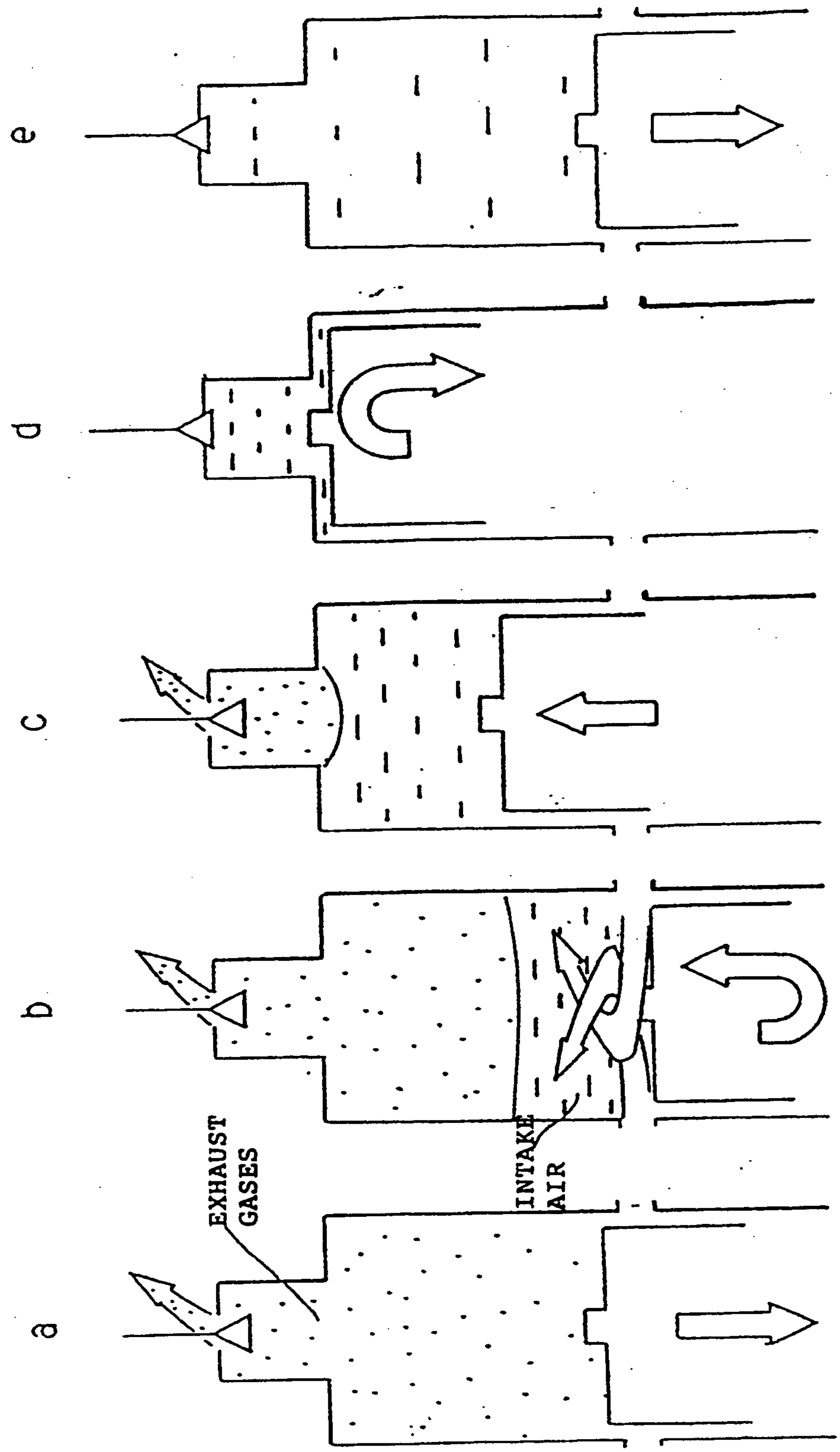
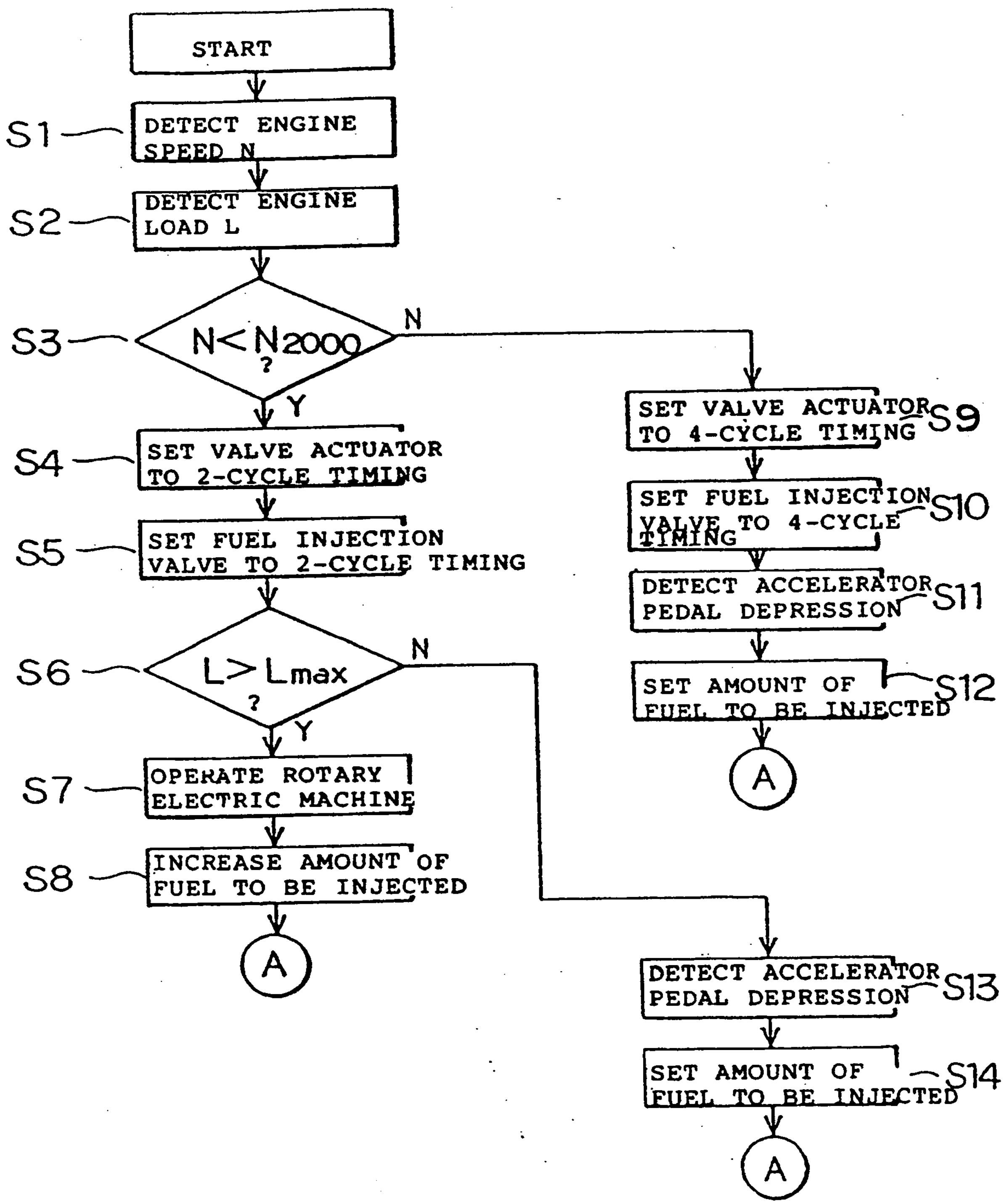


Fig. 7


START
S1 DETECT ENGINE SPEED N
S2 DETECT ENGINE LOAD L
S3 N<N2000 ?
N
Y
S4 SET VALVE ACTUATOR TO 2-CYCLE TIMING
S5 SET FUEL INJECTION VALVE TO 2-CYCLE TIMING
S6 L>Lmax ?
N
Y
S7 OPERATE ROTARY ELECTRIC MACHINE
S8 INCREASE AMOUNT OF FUEL TO BE INJECTED
A
S9 SET VALVE ACTUATOR TO 4-CYCLE TIMING
S10 SET FUEL INJECTION VALVE TO 4-CYCLE TIMING
S11 DETECT ACCELERATOR PEDAL DEPRESSION
S12 SET AMOUNT OF FUEL TO BE INJECTED
A
S13 DETECT ACCELERATOR PEDAL DEPRESSION
S14 SET AMOUNT OF FUEL TO BE INJECTED
A

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 5107

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y,P	GB-A-2219346 (NISSAN MOTOR COMPANY LIMITED) * the whole document *	1-3	F02B69/06 F02D23/02
Y	EP-A-212988 (ISUZU MOTORS LIMITED) * claims 1-4 *	1-3	
A	PATENT ABSTRACTS OF JAPAN vol. 7, no. 275 (M-261) 08 December 1983, & JP-A-58 152139 (NISSAN JIDOSHA KK) 09 September 1983, * the whole document *	1	
A	EP-A-58619 (SOCIETE NATIONALE INDUSTRIELLE AEROSPATIALE) * page 3, line 6 - page 4, line 4 * * page 4, line 27 - page 5, line 16 *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F02B F02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 JULY 1990	ALCONCHEL Y UNGRIA J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

1

EPO FORM 1503 03.82 (P0401)